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# **BEHAVIOUR DETERMINANTS OF THE ‘CHOOSE-SHORT EFFECT’.**



A thesis  
submitted in partial fulfilment  
of requirements for the degree of  
**Master of Applied Psychology in Behaviour Analysis**  
at the  
**The University of Waikato**  
by  
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## **Abstract**

This study aimed to elucidate the mechanisms behind the behavioural phenomenon called the 'choose-short effect' by exploring the hen's ability to discriminate temporal stimuli in delayed match-to-sample (DMTS) procedure. This experiment aimed to add to the understanding of the behavioural processes that affect animals' ability to perceive time and how an animal's own actions can influence their perception of time. The Behaviour Theory of Timing (BeT; Killeen & Fetterman, 1988) assumes that the hens own behaviour mediates their ability to time. This assumption was tested in the present experiment by introducing a 'response-requirement' during the sample stimulus on a two alternative forced choice temporal discrimination. If the assumptions of BeT are correct the response requirement should increase accuracy with temporal discriminations as it can serve as discriminative stimulus signalling in the passage of time. Each hen experienced two experimental phases called 'No-response required' (NR) and 'Response required' (RR) in a DMTS procedure. In the 'NR' conditions the house light was illuminated for either 3 s or 9 s serving as the 'sample' stimuli. After the sample stimulus was presented the 'back-key' was illuminated and the first response to the back-key activated the choice keys after a randomly selected delay of either 0 s, 3 s, 9 s or 12 s. For the 'RR' condition the procedure was the same as the 'NR' condition apart from the 'back key' was illuminated throughout the sample presentation. Results showed that there was no particular group bias towards reporting stimuli as 'short'. However, the hens had higher accuracy in the 'RR' conditions when the 'back key' was illuminated throughout sample presentation than when it was not ('NR' conditions). This suggests that the animals own behaviour improved their ability to time.

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## **List of Appendices**

A list of appendices, including descriptions and file locations, can be found on the accompanying CD in the file `appendiceslist.docx`.

## **Animals and Timing**

The ability to 'time' is an important adaptation for animals. Learning to time, whether it is phylogenetic (inherited) or ontogenetic (individual learning), is vital to the survival of the species within a particular environment (Roberts, 1998). Animals' ability and experiences of 'time' are related to types of "zeitgebers", which are the external cues, rhythms and changes, that help synchronize the animal's internal clock to meet the demands of their environment (Roitblat, 1987). For example, the "zeitgebers" could be in the form of a bird's morning song, which signals to humans the sun has risen. Particular environments influence the animal's natural circadian rhythm (Roitblat, 1987). Circadian changes, such as, seasons, transformation from day to night, and different tide flows, all happen within a particular space in 'time' and adjust the circadian clock so the animal can adapt to their environmental conditions (Roitblat, 1987).

**Theories of animal timing.** It's believed that inside most living things there is an 'internal clock', which tracks time. This 'internal clock' works concurrently with the animal's environment and their biology. This 'internal clock' can be stopped, restarted and adjusted based on the animal's needs (Roitblat, 1987). A popular explanation about how animals are able to 'time' events is called the "stop watch analogy". The "stop watch analogy" describes how an animal's 'internal clock' (or 'circadian clock', pacemaker) works and how it regulates the animal's ability to coordinate biology and behaviours based on daily changes in the animal's environment and their ability to time (Buhusi & Meck, 2009; Church, 1984; Gibbon, Church & Meck, 1984). It works metaphorically like a clock inside the individual. The idea is that the animal has a type of oscillator like a 'clock' that has a repetitive motion that is consistent to each interval. Attached to this 'oscillator' is a type of 'controller device' which produces and converts the

repetitive motion to pulses. Each pulse becomes part of a chain that is added to a type of 'carter' which is then converted into a behaviour which is more easily understood by the individual (Buhusi & Meck, 2009; Church, 1984; Gibbon, Church & Meck, 1984). Timing does not need to be one consistent flow, it is flexible and the "oscillators" can be stopped and started at any time. This allows the animal to adapt to any changes that may occur and to monitor intervals.

Church (1978) agreed with the notion of internal explanations for timing, however, he thought emphasis should be also given to the function of the external mechanism such as the function of the animal's own behaviour in timing.

Killeen and Fetterman (1988) proposed a Behavioural Theory of Timing (BeT) to explain how animals time intervals and events by monitoring changes in their 'own' activity (termed adjunctive behaviours). When animals discriminate time they are responding to the changes in a particular 'state', that is signalled by a particular behaviour associated with that 'state' (Killeen & Fetterman, 1988). Much like humans, who use different types of collateral behaviours, such as verbal counts or physical taps for 'counting', animals discriminate time through their own behaviour which acts as a stimulus that they respond to due to previous reinforcement in that state (Fetterman, Killeen & Hall, 1998). These types of behaviours serve as conditional stimuli under which different classes of behaviours (states) occur between reinforced stimuli. The transitions between these 'states' are products from pulses of the animal's 'internal clock'. It assumes that the pacemaker rate (pulses from the internal clock) is reliant on the reinforcement density and where in time the conditional behaviour occurs (Bizo & White, 1994). The shift's between the behavioural states is modelled by the "Poisson process" which suggests that the function of inter-reinforcer interval and time (T) is inversely proportional to the rate of reinforcement (Bizo & White,

1994). The Poisson process is a continuous time counting process that uses hypothetical pulses from the pacemaker that moves the animal through 'sequential' states (Bizo & White, 1994).

Collateral behaviour can be part of a sequence that marks or coincides with a location in time that helps temporal discrimination relative to particular behaviours and may help aid either immediate, prospective or retrospective judgements (Killeen & Fetterman, 1988). Chatlosh and Wasserman (1987) found a correlation between performance and adjunctive behaviours with pigeons. The pigeons that performed with the highest accuracy had the highest number of key pecks and the pigeons that had the lowest accuracy had the lowest number of key pecks on a temporal discrimination tasks. Fetterman et al. (1998) found that animals such as pigeons and rats had mediating and collateral behaviours that helped with their timing. Animals that displayed such behaviours had higher accuracy than those that did not. Harper and Bizo (2000) found that when rats were reinforced for responding during an interval their timing performance improved, demonstrating that when an interval was filled with behaviour that timing performance was improved. Killeen, Fetterman and Bizo (1997) videoed pigeons and observed discrete behaviours during the sample presentation which seemed to be associated with either 'short' or 'long' stimuli. These behaviours predicted which key the pigeons would respond to. Pecking in front of a left key followed a response to the key associated with 'short' and pecking to the front of the right key followed a response to the key associated with long.

**Delayed matching-to-sample procedures with animal timing and memory.** Delayed matching-to-sample (DMTS) is one of the most widely used procedures in researching 'memory' and 'timing' with animals (Spetch & Wilkie, 1983). The procedure was built on the ideas of Hunter (1913) and the structure of

Blough (1959) as shown in Figure 1.1, when they researched how long a discriminative stimulus has control for when it is no longer present. Raslear, Shurtleff and Simmons (1992) used DMTS procedures to see if their subjects had particular biases for short or long stimuli, and whether these biases are more pronounced when delays were added. They found that adding delays did affect the rats' accuracy on temporal trials as the rats had a bias towards reporting stimuli as 'long'. DMTS procedures consist of four main components in the following sequence, (a) the presentation of the sample stimulus, (b) the onset of particular delay before (c) the presentation of comparison stimuli that has two or more options, to which one matches the sample stimuli and (d) reinforcement of correct matches (Spetch & Wilkie, 1983). DMTS procedures are much like 'match-to-sample' (MTS) procedures; however, there is focus on the manipulation of delay (b) between sample stimuli and comparison stimuli, whereas MTS procedures usually have no delay.

Signal detection theory provides a way of analysing any biases towards one stimulus over another. Raslear, Shurtleff and Simmons (1992) used and applied a formula based on Grier's (1971) work using signal detection analysis to examine whether their rats had biases to report stimuli as 'short' (target) or 'long' when delays between sample and a comparison were introduced. They also examined the effects of increasing the inter-trial-interval (ITI) and manipulating the reinforcement rate on DMTS performance with their rats. They found that their subjects had biases towards reporting stimuli as 'long'. That, is the rats reported more "correct rejections" and 'misses' than 'hits' and 'false alarms'. Figure 1.2, shows the four possible outcomes of a DMTS procedure, a hit, false alarm, correct rejection or false rejection. If the 'short' stimulus is taken as the target and the long stimulus is taken as the absences of the target, then hits (H) are

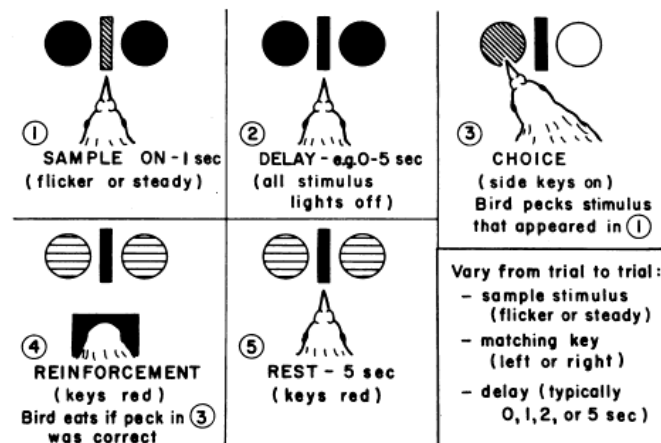


Figure 1.1. Demonstrates the sequence of events for a DMTS trial, used in Blough's (1959) research with pigeons (Blough, 1959, p. 52).

		RESPONSE	
		"SHORT"	"LONG"
SIGNAL	SHORT	HIT $e^{-s/t}$	MISS $1 - e^{-s/t}$
	LONG	FALSE ALARM $e^{-L/t}$	CORRECT REJECTION $1 - e^{-L/t}$

Figure 1.2. Matrix describing hits, misses, false alarms and correction rejections, and their mathematic expressions that can be used to calculate the probability of these occurring according to Killeen and Fetterman (1988) (Raslear, et al., 1992).

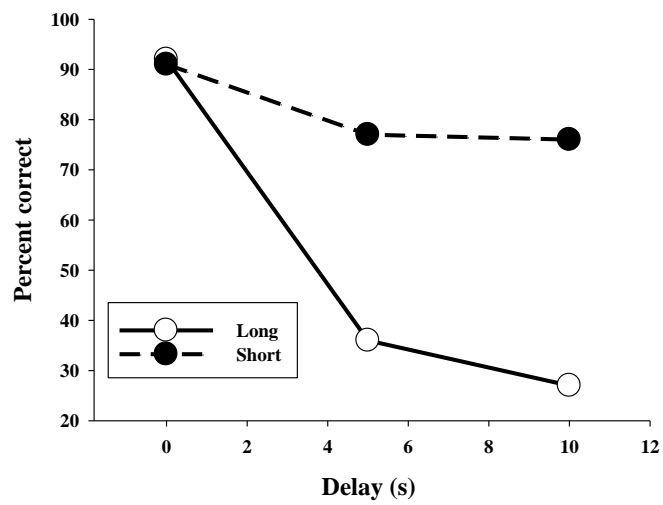


when the sample is 'short' and reported 'short'. A false alarm (FA) is when the sample is 'long' and reported 'short'. A correct rejection (CR) when the sample is 'long' and is reported 'long' and false rejection (FR) when the sample is 'short' and reported as 'long' (Raslear, et al., 1992).  $H$  signifies that probability of a hit and  $F$  is the probability of an FA.

### **The Choose-Short Effect**

**What is the 'choose-short' effect?** The 'choose-short effect' describes a bias that has been observed when an organism is discriminating between two time-based samples, i.e. whether a stimulus is 'short' or 'long'. The 'choose-short effect' occurs when the organism repeatedly reports a stimulus as 'short' over 'long' in a MTS procedure. This bias towards 'short' has been shown to increase with delay between sample presentation and comparison stimuli (Spetch & Wilkie, 1982). Figure 1.3 shows data illustrating the "choose-short" effect, where an animal has higher accuracy with 'short' temporal discrimination and much lower accuracy with 'long' temporal discrimination trials (Spetch & Wilkie, 1982).

**What does the research say?** The term "choose-short effect" came from Spetch and Wilkie (1982), as they were naming an effect they had found in their 1982 experiment when extending their findings from their 1981 experiment. They aimed to examine pigeon's ability to discriminate time and how long they could 'remember' the sample stimuli for and whether the type of sample stimuli affects discriminations. Three pigeons were trained on a DMTS procedure. The sample stimuli was presented in two forms, illumination of feeder for food access ('biologically significant stimuli') and illumination of house light ('neural' non-signification stimuli). Each sample type was presented for either 2 s (short) or 10 s (long) durations. The pigeons would then select the comparison keys that was associated

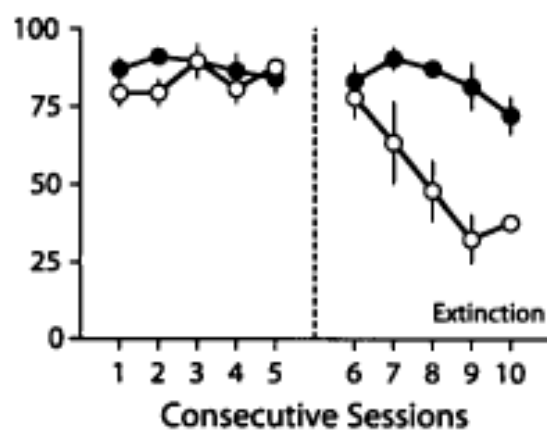


*Figure 1.3.* Adapted from Spetch and Rusak's (1989), a line graph of the Mean percentage correct for 'short' or 'long' trials as a function of delays (s).

to the duration they had just experienced, either 'short' or 'long' and pick the associated colour key. Comparison keys were red and green and the position of the colour varied among the keys to reduce key bias. Between the sample stimulus presentation and comparison keys there were delays experienced across three different series: Series one varied between 0 s, 1 s, 2 s, 3 s, 4 s, and 5 s, Series two between 0 s, 5 s, and 10 s and Series three between 0 s, 5 s, and 20 s, followed by an onset of an ITI of 30 s. They found that acquisitions of the discrimination's were better among trials with 'biologically significant stimuli' and accuracy was higher at the 0 s delay than 'neural non-signification' stimuli. However, when the delay increased, accuracy among the two types of sample presentations became more similar and a pattern started to immerge. The pigeons at larger delays favoured the comparison stimuli associated with 'short' then comparison stimuli associated with 'long' resulting in higher performance when a 'short' trial was delivered than 'long'. Church (1980) first reported this bias associated with 'short' as his rats had a tendency to report stimuli as 'short' when discriminating between durations with 2 s ('short') stimuli and 8 s ('long') stimuli. The initial purpose of Church's (1980) experiments was to study the effects of how 'memory' depletes and changes over time. Experiment 3A, used four retention intervals (RI) (0.5 s, 2 s, 8 s and 32 s) on a two choice DMTS procedure. Church demonstrated that when the delays were increased between presentation of the sample and comparison stimuli, especially with delays at 32 s, the rats displayed a bias to 'choose-short'. Church (1980) concluded that the bias or 'preference' to choose the lever associated with 'short' was not due to 'forgetting' rather the rats were 'guessing', as the trials with the retention interval (RI) of 8 s had fewer errors then RI of 2 s, so when the organism could not discriminate they had a default to choose the lever associated with 'short' (Church, 1980).

Ward and Odum (2007) trained four pigeons in a MTS to classify different intervals of time as either 'short' or 'long' by pecking the coloured key associated with either 'short' or 'long' durations. The pigeons experienced four conditions with the same MTS but with different 'disruptors', and the responses were compared with a baseline with no disruptor. The first 'disruptor' condition involved additional food being given one hour prior to sessions. The second 'disruptor' condition involved additional food being given during the session in the ITI. The third 'disruptor' condition involved flicking light occurring during the sample presentation and the fourth 'disrupt' condition was 'extinction' where only 63% of correct responses were reinforced. The pigeons responded reliably to all trial types with no bias in the baseline conditions but had a 'choose-short' effect in all four 'disruptor' sessions. 'Extinction' trials produced the most pronounce 'choose-short' effect, as seen in Figure 1.4 (Ward & Odum, 2007).

Spetch and Wilkie (1983) investigated whether the way the sample stimuli or delay is presented had any effect on the occurrence of the 'choose-short' effect. They conducted several experiments, which lead to Experiment 4. In one experiment, five pigeons were taught variations of a DMTS procedure with sample stimuli of 2 s and 10 s. The comparison stimulus keys were illuminated either with red or green lights and were associated with either 'short' or 'long', there associations were counterbalance among the pigeons. They manipulated the way the comparison stimuli and delay were presented. Half the pigeons experienced the sample presentation with the illumination of the 'middle' key and the other half with the illumination of the 'house light'. Also the delays were either presented in an increasing stepwise model, decreasing stepwise model or they were randomised. The 'choose-short' effect was present when the delay between the sample stimuli and comparison stimuli were 10 s or more. A stepwise



*Figure 1.4* .Mean percentage correct for both 'short' and 'long' trials for baseline (left) and extinction sessions (right) (Ward & Odum, 2007).

increase in delay produced an initial 'choose-short' effect, also a stepwise decrease in delay produced a 'choose-long' effect. Results showed more training and exposure to the trials with particular delays decreases the 'choose-short' and 'choose-long' effects. Spetch and Wilkie (1983) concluded that the 'choose-short' effect is a real phenomenon and reliably occurred regardless of the form (colour, time) of the sample and comparison stimuli. Regardless of which delay modification procedure is used or type of choice procedure (two-choice or three-choice) and whether the organism has prior experimental histories.

Harper and Bizo (2000) found a 'choose-short' effect when researching whether rats' own behaviours between delays could increase accuracy in temporal discrimination tasks. In this experiment, six rats were training to discriminate 3 s and 9 s durations in a symbolic-match-to-sample procedure. This procedure had four different conditions and the sample stimulus delivered in two different forms, light and tone. The four different condition types were 'light' with 'response required' (1), 'light' with 'no response required' (2), 'tone' with 'response required' (3) and 'tone' 'no response required' (4). The difference was whether the sample was 'light (1 and 2)' or 'tone (3 and 4)' and whether there was a requirement of a press to the lever on the back wall (1 and 3). Firstly, the rats were shaped to press a single lever for reinforcement, once they had mastered the lever press then they were trained to respond to the lever to turn off the associated light. Then the rats were trained to associate the two different levers with corresponding sample stimuli 3 s (for the left lever) and 9 s (with the right lever). After training was complete the testing trials began. The trials started with the presentation of the sample stimuli either in the form of 'light' or 'tone' with the duration of either 3 s (short) or 9 s (long). For the trials that 'required a response' the lever was available during the presentation, however, it was only the press to

the lever after the sample stimuli presentation that would turn off the stimulus. For 'no response required' trials (conditions 2 and 4) the choice levers became available when the sample stimuli presentation had finished. Once a response to one of the choice levers was given the levers retracted and the associating lights blacked out. Incorrect responses resulted in activation of the ITI for 30-s and correct responses allowed access to 2 s of reinforcement before the onset of 30 s ITI. ITI's were a black out for 30 s until next trial began.

Harper and Bizo (2000) results showed that rats displayed higher accuracy in the 'light' trials than 'tone'. Out of the four condition types, accuracy was highest among the trials that used light as a sample stimuli and when the rats were required to respond to the rear lever. The lowest was with the sample that used tone and when the rats were not required to respond during the sample presentation. Also they found a 'choose short effect' presence and that the effect increased when the delays increased. Interestingly the 'choose-short' effect was more pronounced with 'light', even though accuracy was higher. The choose-short effect was also more pronounced in 'no response required' trials than 'response required' trials which could suggest that the response requirement could be assisting mediating timing.

### **Current Study**

This study aimed to elucidate the mechanisms behind the behavioural phenomenon called the 'choose-short effect' by using DMTS procedure with hens. This experiment expected to add to the understanding of fundamental cognitive and behavioural processes that exist across animal species, their ability to perceive time and how an animal's own actions can influence their perception. The current study investigated if hens produced the 'choose-short effect' like other avian species (pigeons) and other animals (rats, monkeys), and whether introducing a

response requirement helped the hen's mediate time and so would eliminate any 'choose-short' effects. This experiment will also allow for a cross-species comparison where the hens' performance could be compared with monkeys, pigeons and rats from previous publications on the "choose-short effect" (Spetch and Wilkie, 1983; Harper & Bizo, 2000). The basis of the study and experiments was from the BeT (Killen and Fetterman, 1988) and the procedures from Harper and Bizo's (2000) experiments.

Harper and Bizo's (2000) experiment with rats used the DMTS procedure where they compared sample stimuli presentations, light verses tone. Harper and Bizo (2000) found that light produced the highest accuracy compared to tone among trials, and also that on 'no response required' trials the rats had a higher 'choose-short' effect. Therefore, 'light' should be a good sample stimuli to use as the accuracy of discriminablity should be high (not left to chance) and would be more likely to produce the "choose-short" effect. Harper and Bizo (2000) used 3 s and 9 s as the sample stimuli, and ITI of 30 s, however, the ITI was slightly altered in this experiment for balancing to make sure all trials were the same length and prevent "choose-short" effects happening as a result of any possible instrumental effects. Bizo and White (1994) found evidence that trials with shorter ITI increased reinforcement rate which would increase the pacemaker rate, therefore, increasing the animal's bias towards short as this would be reinforced more also the arousal would increase the animal's perception of time. To compensate for this short trials were followed by an ITI of 30 s and long trials were followed by an the ITI of 24 s as the difference between short (3 s) stimuli duration and long (9 s) is 6 s. Harper and Bizo, had "no explicit retention interval" (p.52) so the current experiment used, 0 s, 3 s, 9 s,12 s to parallel Spetch and



Rusak (1992) experiment with 2 s, 4 s, 6 s, 8 s as their delays, and with 2 s and 8 s as the sample stimuli.

The BeT (Killen and Fetterman, 1988) assumes that the hens will produce the ‘choose-short’ effect with trials that require no particular response during sample presentation and trials with long delays than those with short or no delays. It also assumes that the effect to ‘choose-short’ will diminish when a response is required during sample stimuli and adjunctive behaviour will aid the animal with timing and increase accuracy in discriminating both short and long. Finally, this study will compared the results from both condition types to see if any mediating behaviours served to improve timing or disrupt timing. The experiment will also manipulate the ‘delay’ between sample presentation and comparison stimuli to compare performance and get an idea of where the ‘choose-short effects begins to occur.

## **Method**

### **Subjects**

Eight brown shaver hens (*Gallus gallus domesticus*) served as subjects. They were approximately three years old at the start of the experiment and had previous experience with pecking keys according to ratio schedules of reinforcement.

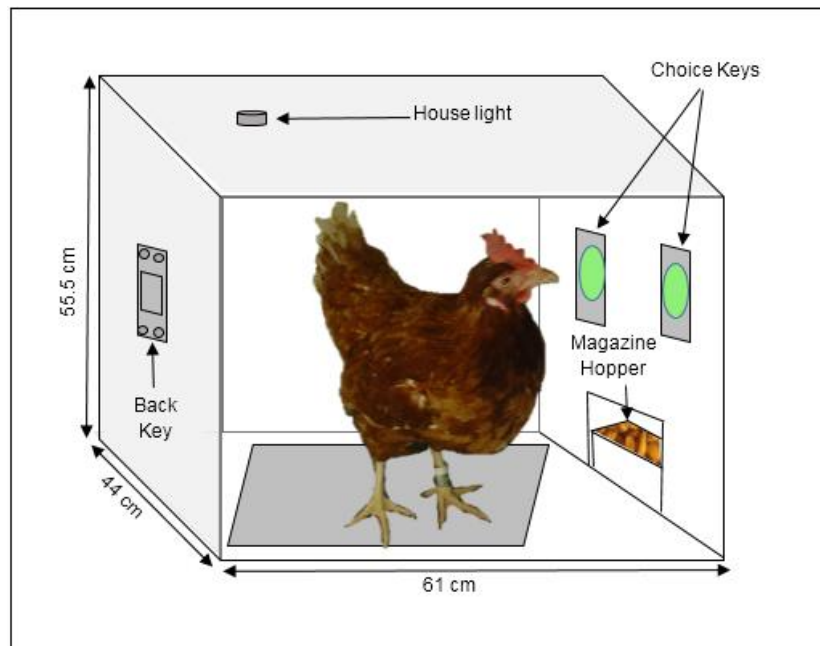
Hens were housed in rooms with timed access to lighting (light on at 6 am and lights off at 6 pm). The hens had individual home cages measuring 460 mm high x 300 mm wide x 440 mm deep. The hens had free access to water and six small lengths of polypropylene twine (white string) that served as an enrichment device in each home cage. The hen's body weights were kept at 85% +/- 5% of their ad-libitum body weight that was established prior to the experiment. The hens were given supplementary food as required after experimental sessions to maintain the individual hen's body weight.

The experimental trials took place in experimental chambers in a room separate from the hens' home cage. The hens earned the majority of their food (wheat) during the experimental session. If the hens did not receive any post experimental feeds for a week then the hens were given a supplementary feeds of vitamins and health grit that week. This experiment was approved by the University of Waikato Animal Ethics committee (protocol 826).

### **Apparatus**

The experiment used two similar operant chambers that each measured approximately 555 mm high x 610 mm wide x 440 mm deep, (see Figure 2.1).

The chamber walls were made from white laminated particle board. Each chamber contained three response keys that could be lit with white LEDs. Two of the response keys were mounted on the front response panel and the third



*Figure 2.1. Panel A.* A diagram of the dimensions of the operant chamber used in the experiment. *Panel B.* Photographs of one of the operant chambers used in the experiment, with one of the subjects.

response key ('back key') was mounted on the rear wall of the chamber. There was a house light with a cluster of four white LED's positioned in the ceiling of each chamber that, when illuminated, signalled the duration of the 'sample stimulus'. Correct responses were reinforced with 1.5 s timed access to wheat via a central food hopper that was positioned 150 mm below the 'choice keys' at the end of an aperture, situated at the bottom middle of the chamber. Across the front of the hopper was an infra-red beam, that when broken, allowed timed the access to the wheat. If the sensor beam was not broken the hopper was lowered after 3 s. Each chamber was linked to a desktop computer, Med Associates control equipment, and an experimental program written in Med-PC 4.0 which controlled and recorded experimental events.

## **Procedure**

Four hens were assigned to each chamber, and for each group of four hens the 'choice' key associated with 'short' or 'long' stimuli was counterbalanced across animals. The order of conditions was the same for all but one hen. The hens experienced the conditions in a repeated measures design (see Table 1). The attempt to counterbalance the order of the starting of the conditions was disrupted by illness and death of three of the hens over the course of the experiment, which was unrelated to the experimental procedure. Hens experienced one experimental session per day, and the experimental sessions were scheduled between 7:00 am and 3:00 pm, seven days a week.

**Continuous reinforcement schedule (CRF).** Hens were initially trained to eat from the magazine hopper, and then to peck all 'response keys' and 'back key' reliably when they were illuminated. Hens were then trained on a CRF to peck all keys reliably when illuminated. The trial began with the 'back key', 'right choice key' or 'left choice key' illuminated as the 'target'. The

Table 1a

*Number of Training Sessions for Each Hen for Both 'Short' and 'Long' Trials for Part 1 of the Experiment.*

Hens	Group	Training			
		CRF	Phase 1.	Phase 2.	Phase 3
13.1	1	14	0	46	6
13.2	1	14	0	34	5
13.3	2	7	7	15	10
13.4	2	14	0	35	14
14.1	2	14	11	18	5
14.2	1	14	7	23	5
14.3	1	14	7	21	23
14.4	2	14	7	23	11

*Note. Hen 14.2 did not complete the RR2 condition due to death or illness.*

Table 1b

*Number of Training Sessions for Each Hen for both 'Short' and 'Long' trials for Part 2 of the Experiment.*

Hens	Group	Training			
		CRF	Phase 1.	Phase 2.	Phase 3
13.1	2	0	11	19	5
13.2	2	0	11	13	5
13.3	1	0	8	14	6
13.4	1	0	11	18	13
14.1	1	0	10	21	5
14.2	-	-	-	-	-
14.3	2	0	14	13	11
14.4	1	0	11	14	10

‘target’ key was the only key illuminated and remained illuminated until a peck was made to this key. The first correct peck to ‘target’ key resulted in timed access to wheat for 1.5 s via the magazine hopper. Incorrect pecks or other behaviours were not recorded and had no scheduled consequences. A new trial began after a reinforcer had been delivered and an ITI of 0 s had elapsed. The order of the ‘target’ presentation was randomized across all three ‘keys’ with the same amount of trials for each. The hens experienced CRF training for 14 days apart from 13.3 who experienced the training for seven days, see Table 1a.

**Matching-to-sample training (MTS).** The training for the matching-to-sample (MTS) condition contained three phases; MTS with only the correct response key lit (Training Phase 1), MTS with both response keys lit with a correction procedure in place (Training Phase 2), and the final training phase, MTS with both response keys lit with the removal of the correction procedure (Training Phase 3). Trials in each training phase started with the presentation of the ‘sample stimulus’, which was the illumination of the house light for either 3 s or 9 s. After the ‘sample stimulus’ duration the house light was turned off and the ‘back key’, which was mounted on the rear wall was illuminated. After a peck to the back key when it was illuminated, the choice keys on the front wall were illuminated. For the first training phase only the key deemed ‘correct’ for the duration of the ‘sample stimuli’ was illuminated, for the other two training phases both choice keys were illuminated. Pecks to the correct ‘choice key’ resulted in food access; incorrect responses resulted in no reinforcement. After the delivery of the consequences an ITI started. The ITI was 24 s if following a ‘long’ sample stimuli trial or 30 s if following ‘short’ sample stimulus trial. During the ITI the chamber was ‘blackened’ out. A correction procedure was employed during Training Phase 1 and Training Phase 2 until the hens met a

criterion of 80% correct for at least seven days for each Training Phase (see Table 1). In this correction procedure incorrect response resulted in the previous trial being repeated until the correct response was given. Sessions ended when 50 reinforcers were obtained or after 40 min, whichever occurred first. Training was complete when 80% accuracy was obtained for 5 consecutive days on Training Phase 3.

**Test.** All hens experienced “No-response required (NR)” and “Response required (RR)” conditions twice using a repeated measures design. The order of the conditions is given in Table 2. The primary manipulation between conditions was the absence or presence of illumination of the ‘back key’ during the sample presentations. The experiment was split up into two parts, Part 1 and Part 2. Part 2 was a duplication of Part 1, however, to reduce any key bias the “choice keys” were counterbalanced. For example, if the hen experienced the left key associated with the ‘short’ stimuli and right key associated with ‘long’ stimuli in Part 1 then in Part 2 short stimuli will now be associated with right and long stimulus with left.

### **Delayed matching-to-sample (DMTS)**

**“No-response required (NR)”.** Each trial began with the illumination of the house light for either 3 s (short) or 9 s (long) (the sample stimuli) and the ‘back key’ was blacked out. After the presentation of the sample stimuli the ‘back key’ became activated. The first peck to the ‘back key’ after the end of the ‘sample stimuli’ started a delay of either 0 s, 3 s, 9 s or 12 s. After this delay both the ‘choice keys’ were illuminated. Correct identifications of short or long stimuli were reinforced. Trials were separated by an ITI that was either 30 s if the proceeding trial was ‘short’ or 24 s if the proceeding trial was ‘long’. After the ITI a new trial began. Sessions terminated after either 50 reinforcer deliveries



Table 2

*Number of Test Sessions for Each Hen for the Experiment Condition for Both 'Long' and 'Short' Trials.*

Hens	Test			
	NR1	RR1	NR2	RR2
13.1	35	29	20	20
13.2	33	31	20	20
13.3	25	21	10 *	*
13.4	30	34	20	20
14.1	20	25	22	18
14.2	20	20	*	*
14.3	32	22	21	*
14.4	31	↔ 20	25	24

Note. Group 1 is indicated by shaded boxes and Group 2 is indicated by white boxes. \* indicates incomplete data due to death or illness. NR1 is “No- response required” and RR1 is “Response required” for Part 1 of the experiment. NR2 is “No- response required” and RR2 is “Response required” for Part 2 of the experiment.

were obtained or 3600 s had elapsed. Delays of 0 s, 3 s, 9 s or 12 s were randomized across trials and each delay was presented equally as often within each session. This process is outlined further in Figure 2.2.

***“Response required (RR)”***. The “RR” DMTS sessions followed the same procedure as “NR” DMTS sessions except for the activation of the ‘back key’ during the sample presentation at the beginning of each trial, see the differences between Figures 2.2 and 2.3.

The “RR” DMTS Session started each trial with the illumination of the house-light and the ‘back key’ concurrently illuminated for either 3 s or 9 s (the sample stimuli durations). After presentation of the sample stimulus the house-light turned off but the ‘back key’ stayed on until the hen pecked the ‘back key’ in the absence of the ‘sample stimuli’. After this peck was made the rest of the trial was identical to the ‘NR’ trials.

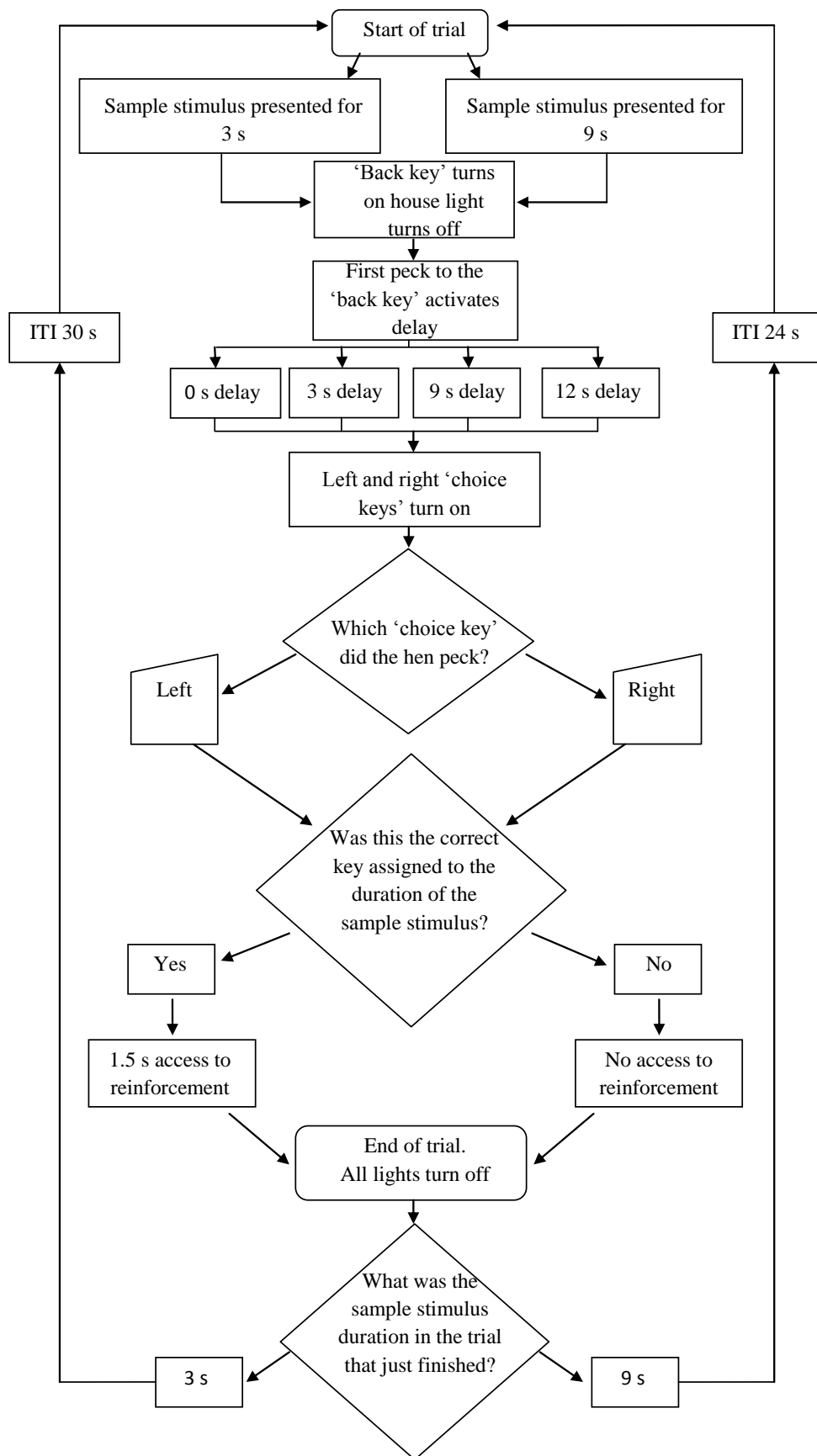


Figure 2.2. Flow diagram demonstrating trials throughout a NR session.

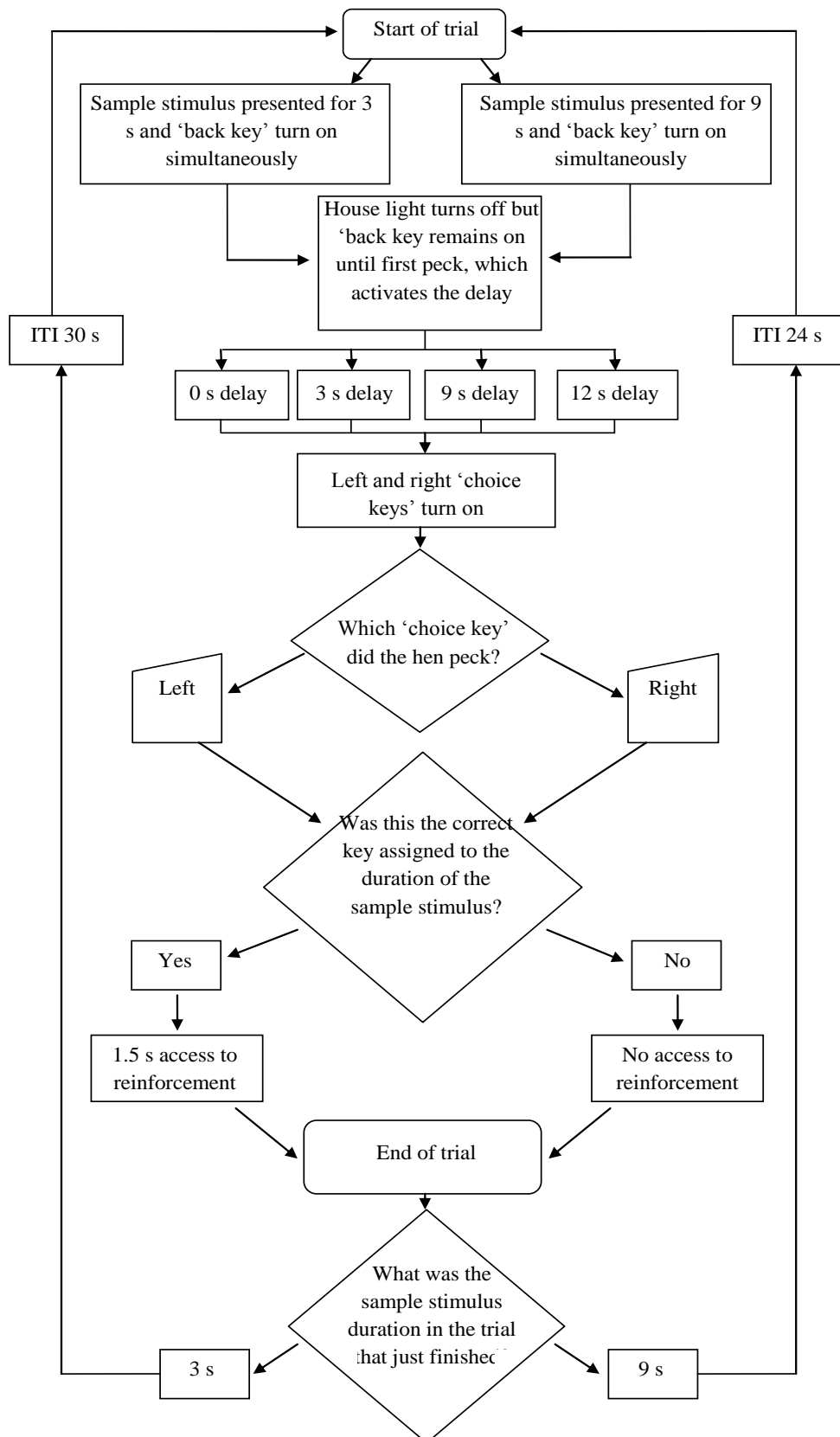


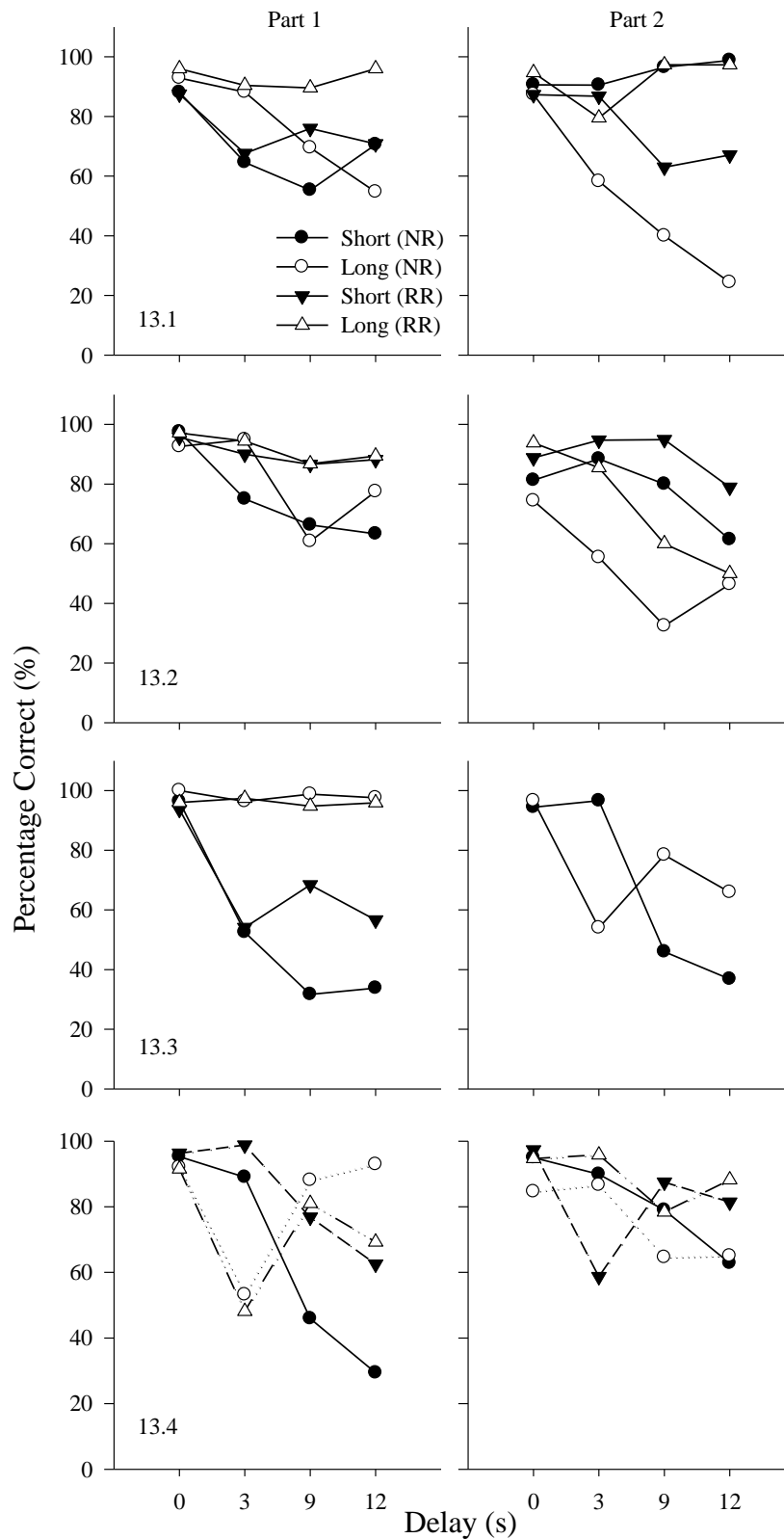
Figure 2.3. Flow diagram demonstrating trials throughout a ‘RR’ session.

## Results

### Percentage Correct

The measures of the hens' performances were based on the mean percentage correct for each trial, delay and condition. Percentages correct were analysed and graphed based on the means of the last 10 days for every trial type (short or long) and condition for each hen. For both the NR and RR components of Part 1,  $N = 8$ . For the NR component of Part 2,  $N = 7$ , and for the RR component of Part 2,  $N = 5$ . The data are shown in the line graphs, Figure 3.1 and Figure 3.2, for each trial type (short or long) over each delay (0 s, 3 s, 9 s, and 12 s). The hens' individual data in Figure 3.1 shows that some of the hens had higher percentage correct for 'short' trials than 'long' (a 'choose-short' effect). However, not all hens had the same bias for 'short' over 'long'. During the NR conditions, the frequency of "choose-short" and "choose-long" effects were relatively similar. Four hens in the NR1 conditions (13.1, 14.1, 14.2, 14.4,) and two in NR2 (13.1 and 13.2) displayed the "choose-short" effect, compared to four in the NR1 (13.2, 13.3, 13.4, 14.3) and three in the NR2 (13.3, 14.1, 14.4) whom displayed a "choose-long" effect. Also Figure 3.1 shows that for the RR conditions, more hens had a higher percentage correct for 'long' trials than 'short' trials. This "choose-long" effect was exhibited by seven subjects compared to only two who displayed a "choose-short" effect. Four hens had higher percentage correct for 'long' trials than 'short' in the RR1 (13.1, 13.3, 13.4 and 14.2) and three in RR2 (13.1, 13.4, 14.1) compared to two hens that displayed the "choose-short" effect, one in RR1 and one in RR2 (14.4 and 13.2, respectively).

Figure 3.2 shows the group mean percentage correct from all hens in Figure 3.1 combined Part 1 and Part 2 both separately (top and middle) and combined (bottom). RR trials produced the highest percentage correct for both



*Figure 3.1a.* Group 13's individual percentage correct for 'short' and 'long' trials at 0 s, 3 s, 9 s and 12 s delays for both Part 1 and Part 2 of the experiment. Part 1 has the first two conditions NR1 and RR1, and Part 2 has the last two conditions NR2 and RR2.

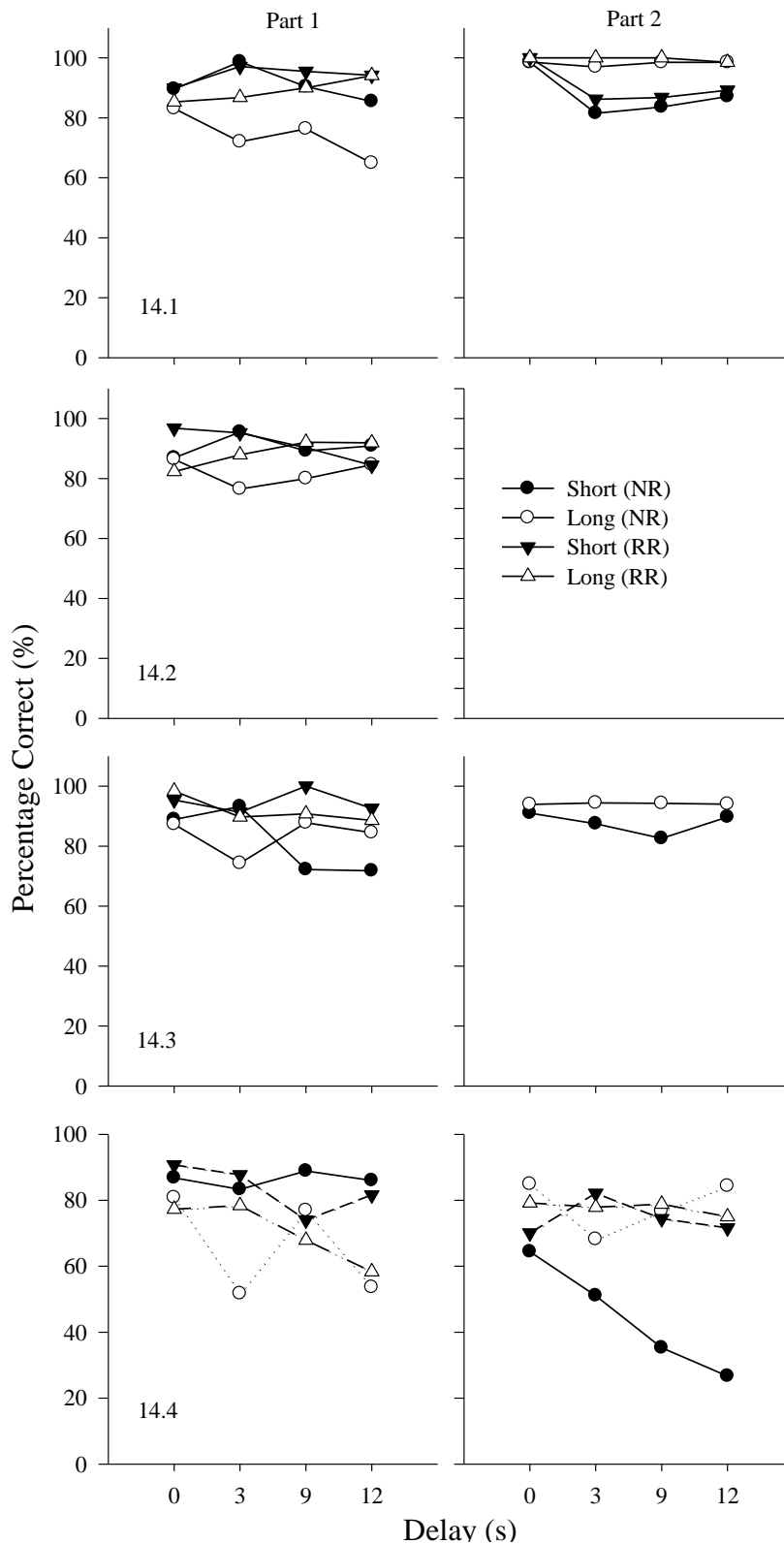
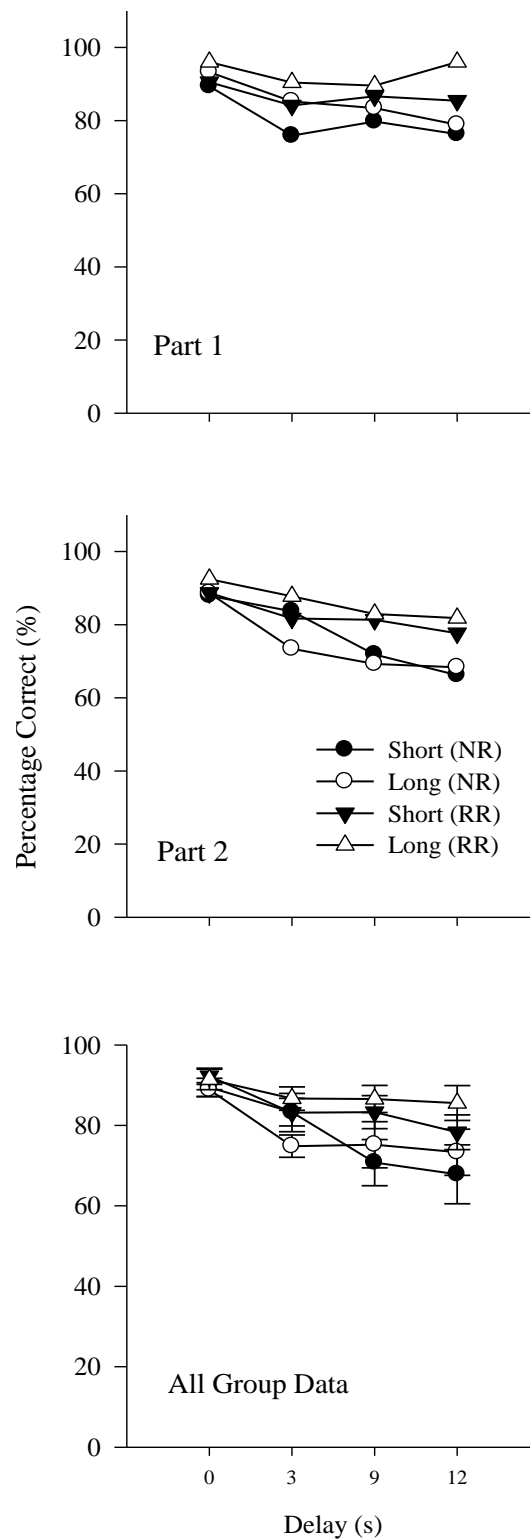


Figure 3.1b. Group 14's individual percentage correct for 'short' and 'long' trials at 0 s, 3 s, 9 s and 12 s delays for both Part 1 and Part 2 of the experiment. Part 1 has the first two conditions NR1 and RR1, and Part 2 has the last two conditions NR2 and RR2.



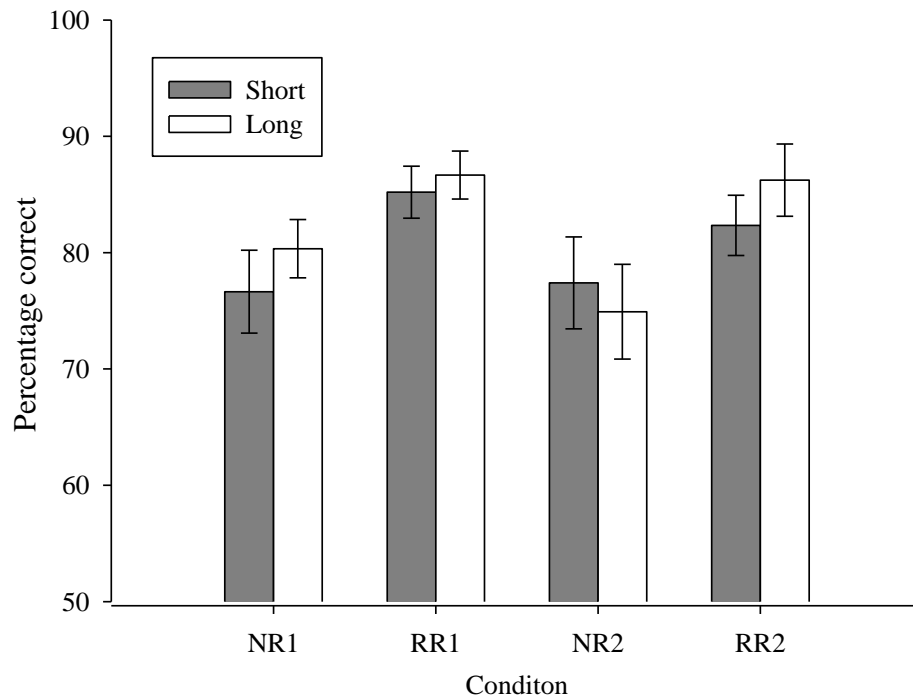
*Figure 3.2.* Percentage correct for all hens for ‘short’ and ‘long’ trials at 0 s, 3 s, 9 s and 12 s delays. (Top) Group data for Part 1. (Middle) Group data for Part 2. (Bottom) Group data for Part 1 and Part 2 combined with error bars.



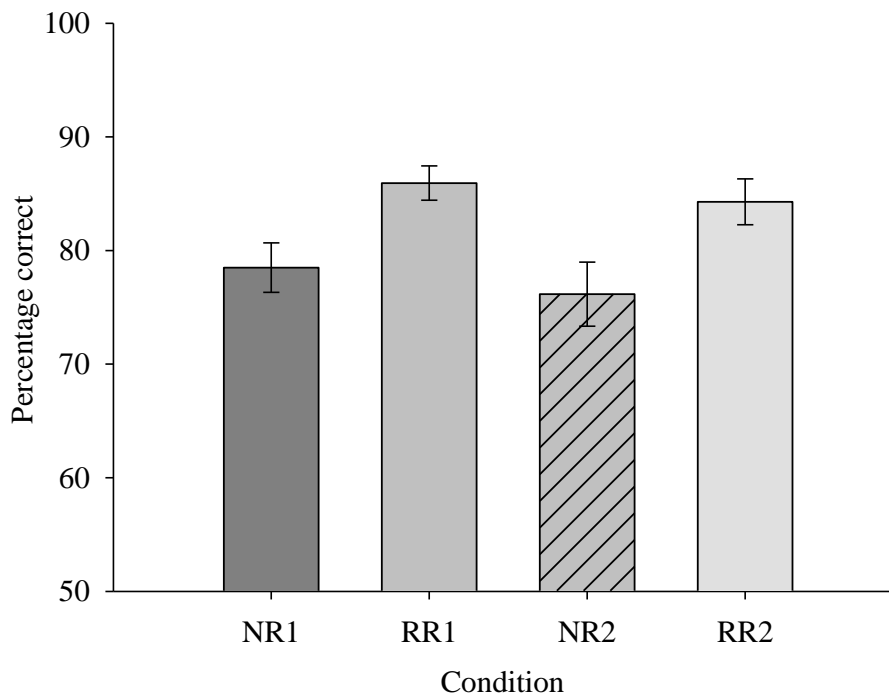
‘short’ and ‘long’ trials reliably among the longer delays (9 s and 12 s). There was the appearance of a slight “choose-long” effect visually present throughout both experiments. Also, as seen in the combined data, NR trials appeared to have the largest error margin across delays at 9 s and 12 s for short trials. Performance between Part 1 and Part 2 that performance noticeably decreases as delays increase for Part 2, but not as much for Part 1. Overall, Figure 3.2 shows that RR trials had the highest percentage correct for short and long trials than NR trials and accuracy appeared slightly better in ‘long’ trials than ‘short’.

Figure 3.3a shows the mean percentage correct for all subjects in both experiments, comparing the performance on ‘short’ and ‘long’ trials over type of condition (NR or RR), without consideration of delay. As shown, hens’ performance for NR1, RR1 and RR2 were superior for ‘long’ trials than ‘short’ but not for NR2. Figure 3.3b was created using the data from Figure 3.3a, however, combining the results of ‘short’ and ‘long’ together for each condition to simplify percentage correct for each condition, NR1, RR1, NR2 and RR2. For all the hens RR trials had the highest percentage correct for both experiments (in Part 1: 85.9% compared to 78.5% and in Part 2: 84.3% compared to 74.2%), regardless of whether the trial was ‘short’ or ‘long’.

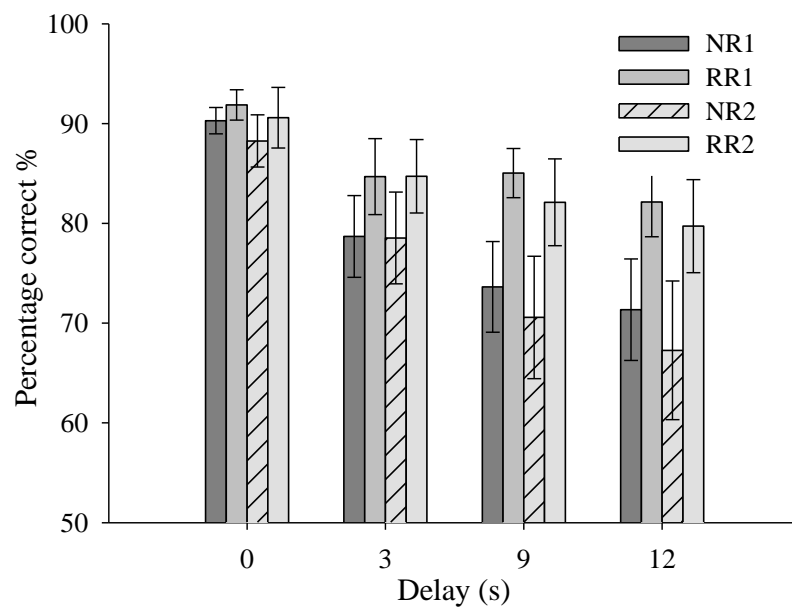
Figure 3.4 shows percentage correct for the different delays 0 s, 3 s, 9 s and 12 s for each condition type. Each bar represents the mean percentage correct for all hens for one of the four conditions, NR1, NR2, RR1 or RR2 for each delay. As seen in Figure 3.4, percentage correct with a 0 s delay had the most consistent (smallest standard error range) and highest accuracy among all trials regardless of condition type. Comparing the four conditions there was a noticeable decrease in percentage correct when delay increased, however, for RR this decrease was less steep. Figure 3.4 shows that the highest percentage correct for all trial types and



*Figure 3.3a.* All hens' percentage correct for 'short' and 'long' trials for each condition: NR1, RR1, NR2 and RR2, with corresponding error bars.



*Figure 3.3b.* All hens' percentage correct combining data for 'short' and 'long' trials for each condition: NR1, RR1, NR2 and RR2 with corresponding error bars.



*Figure 3.4.* All hens' percentage correct for each delay (0 s, 3 s, 9 s and 12 s) for each condition (NR1, RR1, NR2 and RR2) with error bars.

conditions was during the 0 s and 3 s delays and the lowest was during the 12 s delays, which also had the largest standard error.

### **Latencies**

Figure 3.5 shows the latency to respond from when the comparison stimulus was made available to when the hen actually responded. Also the figure showed whether their responses were correct or incorrect for both ‘short’ and ‘long’ trials. The shortest response latency for ‘short’ trials was for ‘incorrect’ trials that had a delay of either 9 s or 12 s. Also both response types for ‘short’ (correct and incorrect) had longer latencies to respond when the trials had a delay of 0 s and shorter latencies with trials that had a 12 s delay. Latencies for ‘long’ responses were smaller when the trial was ‘correct’ regardless of what delay preceded the response, also latencies were smaller with trials with longer preceding delays (9 s and 12 s). In the RR condition, responses on ‘short’ trials had shorter latencies when the hens responded incorrectly than on ‘long’ incorrect trials. However, on ‘long’ trials hens had quicker response times when correct compared to ‘short’ correct trials. Thus, in RR conditions the hens were responding faster on sample stimuli that were perceived ‘long’ regardless whether they were correct or not. Also the hens were reliably taking longer to respond to comparison stimuli when the delay was shorter.

### **Signal Discriminability**

Sensitivity measures A’ and B” are nonparametric measure of response bias and sensitivity which can be calculated using the formulas below. Sensitivity index is based on a ratio of likelihood of responding to whether the sample stimulus is present. Index A’ value usually ranges from 0.5 to 1.0, if the animals performance obtains a score of 0.5 then it is likely the target sample is not

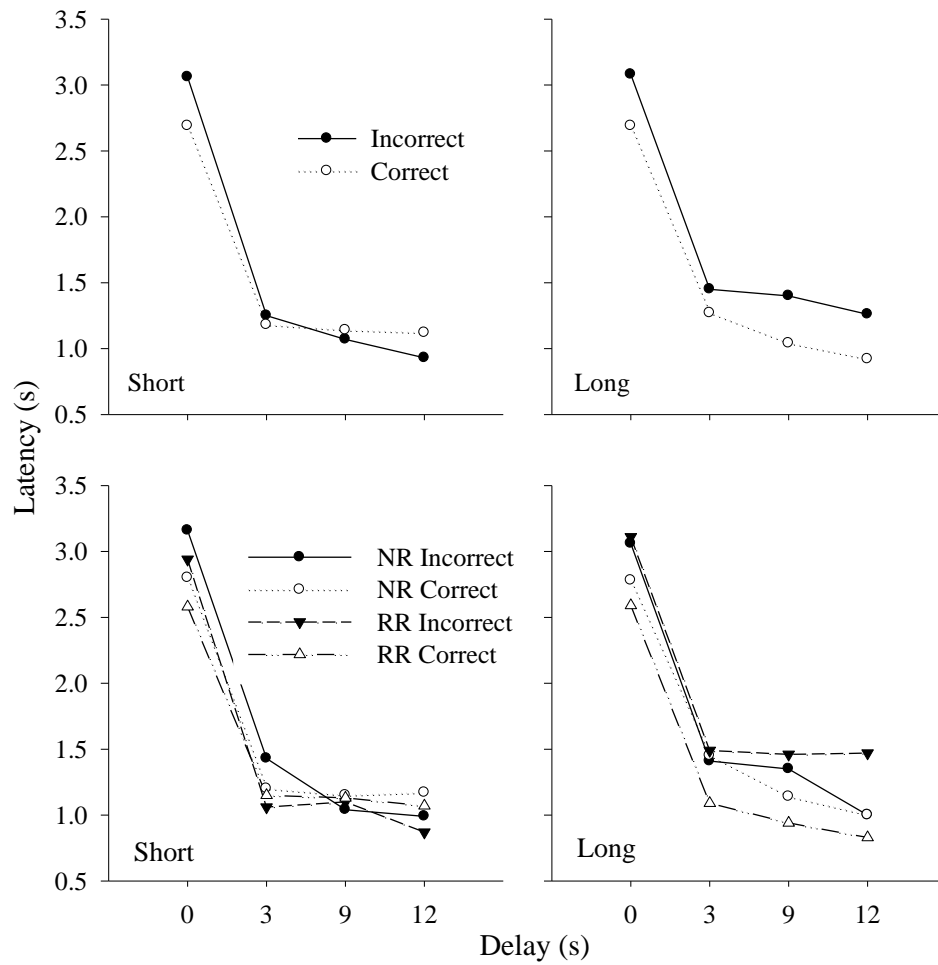


Figure 3.5. (Top) Correct and incorrect responses as a function of latency and delay (0 s, 3 s, 9 s and 12 s) for 'short' (left) and 'long' (right) trials. (Bottom) Correct and incorrect responses as a function of latency and delay (0 s, 3 s, 9 s and 12 s) across conditions (NR and RR) for 'short' (left) and 'long' (right) trials.

detected, however, if the animal obtains  $A'$  value of 1.0 then the animals discrimination is 'perfect' (Raslear, et al., 1992).

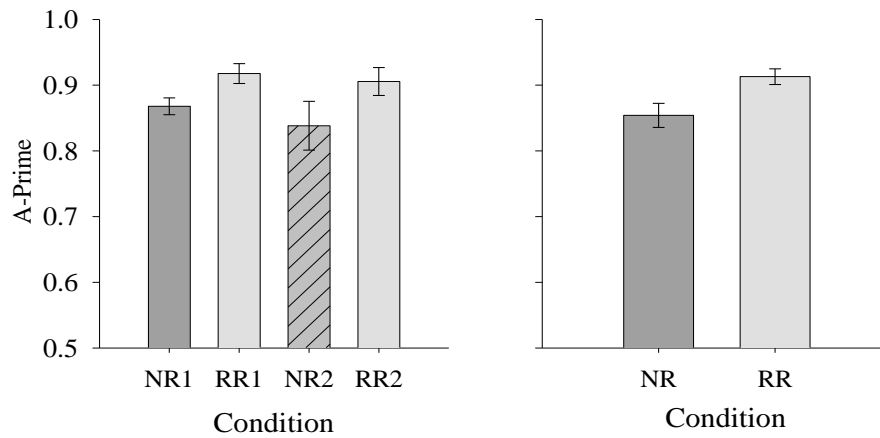
$$A' = \{[(H - F) + (H - F)^2] / [4H(1 - F)]\} + 0.5 \quad (1)$$

And

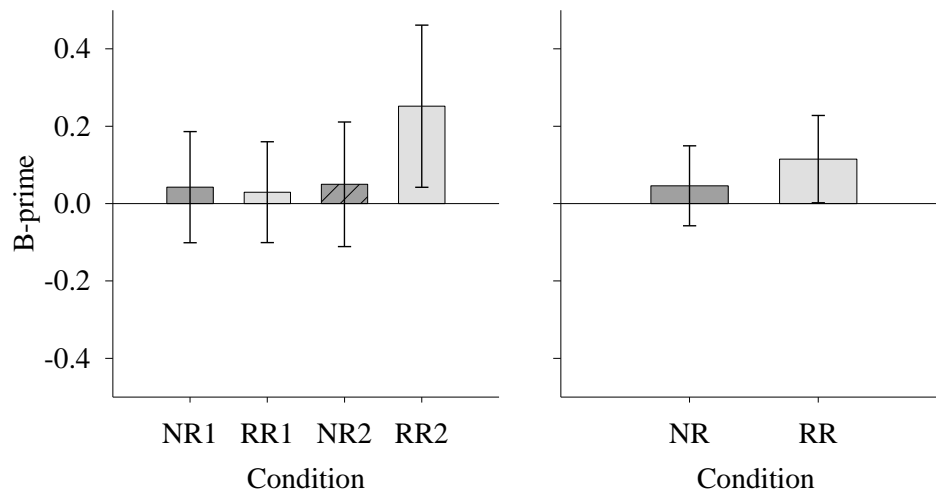
$$B'' = [(H - H^2) - (F - F^2)] / (H - H^2 + F - F^2) \quad (2)$$

(Raslear, Shurtleff & Simmons 1992)

Using the formula from above Figure 3.6 shows the hen's group index of discriminability scores. Figure 3.6a shows  $A'$  prime values and whether the hens were able to discriminate whether the 'short' sample was present within each trial.  $A'$  prime is plotted on the y-axes and condition type (NR and RR) is along the x-axes. The hens obtained  $A'$  score of 0.87, 0.92, 0.84 and 0.91 (NR1, RR1, NR2 and RR2 in respective order). As you can see, the hens were more likely to detected target stimuli (hits) and correctly reject non-target stimuli in the RR conditions than NR conditions for both experiments. However, both condition types reliably demonstrated that hens were very good at discriminating between the presence and absence of 'short' stimuli as all scores were above 0.8 which is regarded as very good. Figure 3.6b shows measure of the level of bias towards either short or long stimuli.  $B''$  values fall between +1.0 and -1.0, positive numbers indicate a bias towards 'long' and negative values would indicate that the organism had a bias to report 'short' (Raslear, et al., 1992). Figure 3.6b shows  $B''$  on the y-axes and condition type on the x-axes. Comparing the two types of conditions RR, with a score of 0.14 gave the stronger biases towards 'long' than NR, with a score of 0.05, however, both gave slight bias towards long. Overall, the discriminability index scores showed that all conditions results in a slight bias



*Figure 3.6a.* A' scores for all hens across conditions NR1, RR1, NR2 and RR2 (left), and across combined NR and RR conditions (right) with error bars.



*Figure 3.6b.* B' scores for all hens across conditions NR1, RR1, NR2 and RR2 (left), and across combined NR and RR conditions (right) with error bars.

towards long stimuli and 'RR' trials had the strongest bias. Also all conditions had a high probability that correct responses were not by chance, thus concluding that long bias that occurred was not by chance.

### **Summary**

Results showed that the 'choose-short' and 'choose-long' effects both occurred within individual hens' data. However, the group data suggest that there were more instances of 'choose-long' effects than 'choose-short' effects.

Sensitivity indexes showed there was a bias towards 'long', that it was not likely to be by chance, and that the hens performed better in RR conditions than NR conditions for both Part 1 and Part 2. Latencies at longer delays (9 s and 12 s) were quicker when the hen selected 'long' regardless if they were correct or what condition type. Hens also generally responded faster to these trials with longer delays than those with shorter delays (0 s and 3 s).



## Discussion

This experiment investigated factors that influence the behavioural phenomenon called the ‘choose-short’ effect. Firstly by creating the conditions in which others have observed the “choose-short” effect, then changing the conditions to see if the magnitude of the “choose-short” effect could be manipulated or reduced. The “choose-short” effect has been described as an effect that occurs in DMTS temporal procedures when an organism is discriminating between two time-based samples, for example, whether a stimulus is ‘short’ or ‘long’ and they have bias to report the sample as ‘short’.

### **Did the “Choose- Short” Effect Occur?**

It was expected that a clear bias for responding towards stimuli associated with ‘short’ over ‘long’ would be observed; however this was not the case. The “choose-short” effect was observed in both conditions of the experiment; however, ‘choose-long’ effects were also observed. Only 6 of 13 hens in the NR condition and 2 of 13 hens in RR showed an obvious ‘choose-short’ effect. Therefore, a higher occurrence for ‘choose-long’ effects than ‘choose-short’ effects was seen in Figures 3.1, 3.2 and 3.3, a bias opposite to what was expected. This was possibly moderated by the availability to make a response during the sample stimulus duration. Different types of analyses were conducted to examine the magnitude of the “choose-long” effect. Looking at the percentage correct graphs in Figures 3.1, 3.2 and 3.3 there was an obvious difference in accuracy in favour of ‘long’ as the percent correct was repeatedly higher. Even though the percentage correct was a good indicator of performance on the two trials types, it does not allow one to assess the degree of bias. Consequently a signal detection analysis was undertaken. When conducting the signal detection analyses to obtain index scores, the extent to which the hens could discriminate ‘target’ stimuli became clearer, the hens were considered ‘very good’ with an A ‘prime score over 0.8 (Figures 3.3a and Figure 3.6). These higher discriminability scores demonstrated that these hens could discriminate with a high level of accuracy. On the surface these findings seem to contradict what we were expecting to find as we thought a “choose-short” effect was inevitable throughout NR conditions. However, through closer inspection and understanding of the BeT model the occurrence of “choose-long” effects in this experiment could have been typical due to the methodologies and temporal contexts, for example, shorter relative RI compared to the ITI used in the present experiment.

### **The “Choose-Long” effect**

The “choose-long” effect is not a new phenomenon. This effect has been seen in several DMTS procedures with different species and various task including discriminations of wavelength and line orientations (Roberts & Grant, 1976; Roitblat, 1980). The “Choose-long” effect is similar to the “choose-short” effect; however, accuracy is higher for “long” stimuli than ‘short’ stimuli. For example, the results of Sakurai (2001) showed a type of “choose-long” effect when studying monkey’s cognitive abilities on temporal task using two types of DMTS procedures. The purpose was to see how information was retained or decayed relative to the length of RI. The first procedure tested was “delay matching to sample of stimulus durations” (DMS-D) which measured discrimination of ‘temporal’ events and the second procedure tested was “delayed matching to sample of stimuli with colours” (DMS-C) to measure discrimination of ‘non-temporal’ events. The only difference between the procedures was the type of stimuli used, whether the monkeys had to match duration or colour and whether the sample and comparison was a ‘match’ or a ‘non-match’. Their results showed that when the RI was increased the monkeys began to make more errors for ‘short’ trials than ‘long’ resulting in a ‘choose-long’ effect especially for DMS-C task than DMS-D task. These findings are interesting as the temporal length of the ‘sample’ stimuli presentation impacted the accuracy for matching colour samples as well as temporal discriminations. DMS-C task was designed to measure the monkeys’ ability to discriminate colour (non-temporal event), however, this condition type produced temporal effects. Also what was found trials with fixed RI’s but variable length of sample stimuli with small difference in duration from ‘short’ and ‘long’ comparison stimuli produced the most errors for DMS-D task than DMS-C task. This seems typical; however, the thought would be that variable RI’s would produce more errors than fixed. This suggests some temporal context effects. In the present experiment the RI was fixed at 0 s, 3 s, 9 s, or 12 s, however, the onset of the RI was dependant on the hen’s latency to respond to the back key. The latency to key peck could be seen as an extraneous variable that has altered the length of RI, thus, losing the potential control of the RI, which could have resulted in an increase of errors towards ‘short’ stimuli trials. It also seemed that trials that had inconsistent temporal backgrounds were more likely to produce “choose-long” effects, which could be an explanation to what happened in this experiment.

### **Changing the Conditions from NR to RR**

There was a noticeably superior performance with higher percentage correct for RR conditions than NR conditions. Hens on average performed better in RR which was even more pronounced at the longer delays. When the condition was changed from NR to RR, accuracy among all hens and among all trial types increased and the “choose-short” effect decreased. When Part 1 was repeated (Part 2) the same results occurred, performance dropped in NR2 condition and increased in RR2 condition and ‘choose-short’ effects reduced in RR condition. Interestingly, the number of occurrences of ‘choose-long’ effect did not decrease in RR conditions; however, the strength of bias did decrease. The “choose-short” effects that did occur decreased when the RR condition was introduced. The RR condition decreased the intensity of both effects and promoted high accuracy for discrimination for both ‘short’ and ‘long’ stimuli but as a group it still did not diminish the “choose long” effects. Also interesting was latency responses (see Figure 3.6) in the RR conditions, for short trials the fastest response time was for incorrect responses and for long trials responses were faster for correct responses. So the hens responded to comparison stimuli associated with ‘long’ quicker than those with ‘short’, regardless of accuracy.

### **Attention as an Explanation of the “Choose-Short” Effect**

The theory of ‘attention effect’ as explained by Church (1980) suggested that the reason the “choose-short” effect diminishes and reduces when animals are required to respond (during the sample stimulus and before the onset of a delay) could be in regards to the animals ‘attention’ to the sample stimulus presentation. When animals are required to respond, they are more involved with the experimental process as the continuation of the trial is conditional on the animal’s correct response. Because the task requires the animals “attention” (response), more ‘awareness’ by default is given to the sample presentation which increases the likelihood of correct matching on DMTS procedures thus increasing accuracies and reducing the “choose-short” effect or any bias. Basically, the theory suggests that it may not be the required behaviour itself being associated with a particular period in time but working as a by-product to focus on the current task. Also when the back key was lit, it could have made the presentation more salient, thus easier to discriminate.

Buhusi and Meck (2009) had another take on how ‘attention’ affects timing ability as they talked about ‘lack’ of ‘attention’ as an explanation to the

“choose-short” effect. When individuals are not required to respond during the sample presentation there is potential for another task (secondary task) to fill in the delay. So when the animals were to report their ‘experienced time’, their ‘experienced time’ became shorter as the interval was filled with a secondary task that has distracted them (Buhusi & Meck, 2009). If humans were required to participate in a secondary task, they had the tendency to report waiting period shorter than it actually was as the ‘distraction’ had become their resource for ‘timing’ (Buhusi & Meck, 2009). So it could be said that the animals in the present experiment could have had a secondary task that was distracting them in the NR conditions which made the delay and sample stimuli appear shorter, thus, increasing the frequency of choose-short effects. However, in the RR condition the secondary task might have been incompatible with the response requirement thus decreasing the ‘distraction’ that is associated with ‘lack’ of ‘attention’ and ‘choose-short’ effects. In NR condition the fact that the ‘back light’ was not on during the sample presentation caused a ‘distraction’ for the hen when it was turned on. The hen could not accurately anticipate the arrival of the ‘back key’ light as all the trials were pseudo-randomly determined so when the ‘back key’ turned on in NR condition it could have been unexpected. The contrast of repeated sessions of light and dark could have physiological effects on the hens, like, light adaptation issues (with eyes) or increase levels of cortisol steroid hormone’, these effects could reduce the hens ability to perform. The trials in RR do not have the same issues as the contrast of light and dark could be expected, also occurred less as the ‘back key’ is already lit throughout the sample presentation and the blacked out delays (RI and ITI) were always onset by the hens own behaviour, so the hen can anticipate this reducing the adverse effects.

### **Type of Stimulus**

Bizo and Harper (2000) found that a temporal discrimination task that used ‘light’ as a sample stimulus had higher accuracy among temporal discriminations than sample stimuli using ‘tone’. However, the ‘choose-short’ effect was more evident with ‘light’ trials than the trials using ‘tone’. This raises the issue of the ‘choose-short’ effect could be a result of the vehicle to which the ‘sample’ stimulus is delivered in and what stimuli is salient or what the temporal background the organism is most familiar with. In this current experiment, when the house light and sample stimulus was simultaneously presented (RR trials) accuracy was higher and this could be due to the sample becoming more

intensified, making it easier for the individual to discriminate as it 'sample' is more salient.

In the Bizo and Harper (2000) experiment, the intensity level of the sample stimuli could have aided discrimination. The rats might have better detection of the 'light' over 'tone' due to the frequency level of the 'sample'. As a result, the rats might have been able to detect light more easily than sound. This might not be a reflection of their ability to time but ability to detect the sample in the first place. However, it could be as simple as the rats just have better vision relative to their hearing, also that the rats they were more familiar with 'light' stimuli than tone, as they were first trained with 'light'. So level of familiarity of 'sample' type could be increasing accuracy. It could be said that discriminating temporal stimuli whether they are 'short' or 'long' might be equally as 'hard' with novel stimuli (tone), then familiar (light), thus reducing bias or particular associations as both trials with 'novel' stimuli are as equally 'hard'.

### **Temporal Context**

The "relative duration" hypothesis suggested that a "choose-short" bias and other errors that occur are due to the individual's temporal context in which encompasses the affects and characteristics of the 'sample' stimuli, the RI and the ITI (Buhusi & Meck, 2000; Spetch & Rusak 1992). This could explain for some days certain hens had a lower accuracy on 'short' trials when the RI was 9s and for 'long' trials when the RI was 3s (as shown in individual raw data and Figure 3.6). Spetch and Rusak (1992) proposed that their subjects' accuracy on temporal trials were reliant on the 'sample stimuli' relative to the temporal context in which events occurred before and after the sample presentation. When the ITI was 'short' responding towards 'short' increased. For example, there was a 118% increase in the subjects responding with a bias towards short when the ITI was 10 s, compared to an ITI of 60s where there was an increase of only 48%. Also when comparing an RI of 0 s to 20 s there was a 48% increase towards responding to 'short' at the longer RI (p.140). Spetch and Rusak (1992) hypothesized that the pigeons have the ability to make discriminations based on ratios of several temporal stimuli in relation to each other. A 'short' ITI contributes less proportionally to the temporal context which relatively increases the RI which then gets compared to the sample stimuli, which seems longer, therefore the sample stimulus appears to be 'short'. With shorter trial lengths (short ITI's) the pacemaker speed increases so will responding to short. This then could explain

why the hens in this current experiment displayed a “choose-long” effect. This experiment had relatively longer ITI’s, either 24 s (for long precedent trials) or 30s (for short precedent trials). So the larger ITI contributed more proportionally to the temporal background than the RI, which by default decreased the perceived temporal length of the RI. When comparing the RI to a sample the RI appears ‘shorter’ thus the ‘sample’ must have been ‘long’. Also in this experiment the onset of the RI of 0 s, 3 s, 9 s and 12 s was actually dependant on the hens’ own behaviour to peck the back key to start the delay. The hens’ behaviour could manipulate the trial temporal context, therefore, increase trial time. Longer trials decrease the reinforce rate and decreased the pacemaker, thus increase a bias towards ‘long’. Human also use ratios or relative durations of events to estimate time. Buhusi and Meck (2009) mention that humans reported ‘waiting periods’ shorter when they could compare tasks that occur within the delay than humans that had no ‘particular’ task to guide their estimations.

### **Limitations**

BeT and the work of Harper and Bizo (2000) and Killeen and Fetterman (1988) formed the bases of the assumptions for the present experiment that the animals own behaviours mediates the ability to ‘time’ and if the hens were able to elicit a response during the ‘sample’ presentation then this would help with accuracy on temporal discrimination tasks and reduce any “choose short” effects. From this experiment additional data for pecks made during the experiment were not collected due to programming issues, so all pecks made other than the one made to the back key that elicited the RI or response to the ‘choice key’ was not obtained or recorded. This was extremely disappointing as this would have given more insight into what was happening in the chamber throughout the different trials and whether any blacked out key pecks were associated with any particular responses or patterns. However, small preliminary sample data on adjunctive behaviours that occurred within the chamber, such as number of pecks was captured on a single video. The video recorded approximately 40 minutes of visual data for Hen 14.1 in the RR condition. This particular video was made post hoc out of curiosity, as the original data was limited only to recording ‘events’ written within the programme. Hen 14.1 displayed topographies that appear to be consistent with a ‘counting’ pattern. The hen appeared to peck the back key on average three times (range 2-5 pecks) when the ‘short’ sample stimuli was present and on average (6-14) nine times when the ‘long’ sample stimuli was present.

This then appeared to mediate her type of response towards the particular ‘choice key’. If the hen pecked approximately 3 times then she would choose the key associated with the ‘short’ and she pecked approximately 9 times then the hen would choose ‘long’. This adjunctive behaviour could be why this particular hens had reliably high percent correct among all the trials. Similar findings were shown in a more controlled experiment by Killeen, Fetterman and Bizo (1997) when they videoed their pigeons and systematically coded each behaviour that occurred. These videos showed that the pigeons displayed particular behaviour repertoires, and that the antecedent behaviours was a reliable predict of what response key they would respond to. If the pigeons pecked in front of the left key then they would choose ‘short (6 s)’ and if they pecked in front of the right key then they would choose ‘long (12 s)’. These behaviours were mediating the pigeon’s response whether it was correct or not, however, it appeared to be aiding in these trials as their accuracy rate was 95%.

### **Future Research**

Further films and recordings within the chamber should be an important aspect when analysing performance on temporal task as they can account for some of the patterns or anomalies that occur that often gets missed due to programming. More research needs to be conducted with respect to the role of animal physiology and sensory perception. Not only is it useful to know what each animal can perceive, but what ‘sample’ stimulus yields the highest accuracy, which then could test for more complex temporal tasks. Also using monitors that test the animal’s heart rate and pulses could provide insight to whether there is an increase in arousal rate due to reinforcement and whether there is correlation to what the animals chooses.

The majority of hens in this experiment had a “choose-long” bias, but this is not the case for all avian species (Spetch & Wilkie, 1982). More research that allows for inter- and intra-species comparisons that look at the importance of ‘timing’ for each animal in their natural environment would also be a good idea. There may also be a correlation between animals that have a shorter life expectancy and the likelihood of ‘choosing short’ – it may have some biological advantage, as the larger animals could perceive time differently and at a ‘different’ slower pace.

Also repeating the experiment with a third option with either the mean between the two sample types, for example, for a sample that is 3 s and 9 s the

third option would either be 6 s (arithmetic mean) or the or 5.2 s (geometric mean) would decrease the occurrence of ‘choose-short’ and “choose-long” biases.

### **Conclusions**

The aim of this experiment was to explore the “choose-short” effect and how the hens’ behaviour mediates their ability to time during temporal procedures with delays. Results found both “choose-short” and “choose-long” effects in both individual data and group data. These findings at first seem to contradict what this experiment aimed to explore as there was no particular systematic bias, and the biases that did occur could be due to the individual differences in each hen’s internal clock and behaviours associated with a particular ‘time’.



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